Fueling the Future:

Transportation Energy in California

EXECUTIVE SUMMARY

California Department of Transportation
Division of Transportation Planning
Office of Policy Analysis and Research

Caltrans

Photo: CNN

According to the CEC, Californians consume nearly 1.1 billion gallons of gasoline each month.

"The goal of this project is to develop an information base and expertise in order to formulate educational programs on the linkages between transportation energy and statewide transportation planning efforts."

Purpose

This study has taken a comprehensive look at transportation energy issues of relevance to California. The study began in August 2002 and was completed in July, 2003.

The major objectives of this study were to compile information across a broad spectrum of topics related to transportation energy and planning, develop an information base for transportation planners, engineers, and policy makers, and educate the public on the benefits of transportation energy efficiency.

This study was guided by the Office of Policy Analysis and Research which is a division of the California Department of Transportation.

The final report, *Fueling the Future: Transportation Energy in California*, contains up-to-date information on transportation energy issues. The report consists of three sections: an Executive Summary, Key Issues and Policy Options Papers, and Technical Analysis Reports. For each section there are nine chapters spanning interrelated issues. The Executive Summary provides a concise summary of the key issues and policies identified in each chapter. The Key Issues and Policy Options Papers include comprehensive analysis and discussion of key issues and policies that affect or have the potential to affect transportation energy. The Papers are targeted at California state, regional and local transportation planners. The Technical Analysis Reports are provided for interested parties seeking more detailed information, focusing on the subject matter identified in the Key Issues and Policy Options Paper for each chapter.

California Transportation Statistics , 2000	
Maintained transportation facilities	
All public roads	168,076 miles
Interstate	2,453 miles
Road bridges	23,672
Class I railroad trackage	5,861 miles
Inland waterways	286 miles
Public use airports	257 (42 cert.)
Vehicle miles of travel (VMT)	163,557 million miles
Number of registered vehicles	28,146,424
Automobiles registered	17.3 million
Light trucks registered	8.9 million
Heavy trucks registered	119,000
Buses registered	47,000
Motorcycles registered	449,000
Rail transit systems	11
Numbered boats	905,000
Transportation fuel consumption, 1999	530 million bbl
Gasoline consumption	336 million bbl
Diesel consumption	64 million bbl
Percent of U.S. motor-fuel use	10.4%

Review of Energy Policies

In California approximately half of the state's energy consumption results from transporting goods and people. With 34 million people and 28 million registered motor vehicles, California is the world's second largest consumer of gasoline and diesel fuel, exceeded only by the remainder of the United States. Gasoline and other petroleum fuels constitute the vast majority of the state's transportation energy. Statewide, there are approximately 9,500 retail fueling stations that dispense a total of 14.1 billion gallons (336 million barrels) of gasoline and 2.7 billion gallons (64.1 million barrels) of diesel each year. This is equivalent to about 5,000 gallons of petroleum fuel per station each day.

As the California population continues to grow and the vehicle miles traveled per capita outpaces that growth, this demand for fuels increases, making it important to understand the policy forces that push the demand higher or lower.

Transportation Economic Policy

California is the fifth-largest economy in the world. Its economic status is dependent upon the accessibility of people and goods within the state, as well as to other states and countries. In California, access is provided by a transportation sector that is dominated by over 160,000 miles of public roads and highways in urban and rural areas. The transportation system also includes critical though smaller networks of rail, maritime and aviation transportation facilities.

Photo: TIAX, LLC

California's transportation sector consumes a mix of fuels that is very different from other energy consuming sectors. Therefore the state's transportation energy production and consumption markets are profoundly different from other energy markets. California's transportation energy usage accounts for about 11 percent of the total 26,324.6 trillion Btu consumed nationally. On a per capita basis, the state uses about 7 percent less energy for transportation purposes than consumers in the rest of the country.

The level of energy demand in the transportation sector is dependent upon the general state of the economy. When the national economy slowed down during the latter half of 2000, it did not take long for transportation and transportation-fuel demand to diminish. This resulted in lower prices for automobile gasoline.

In 2001 the U.S. real gross domestic product for transportation industry was $780.5 billion (in chained 1996 dollars), or 8 percent of the entire GDP. The value of transportation in the economy is revealed in the net rate of return from investments. According to an AASHTO report, the average annual rate of return on investments in the National Highway system is greater than 20 percent, and almost one-fifth of the increase in productivity in the U.S. economy between 1980 and 1991 was attributable to investment in highways.

Revenue and funding to support transportation investment is linked to transportation energy consumption. The primary source of transportation revenue is the excise tax collected on each gallon of gasoline and diesel fuel. Despite the increase in fuel consumption, the value of this revenue is steadily diminishing because the taxes have not kept pace with inflation. There is therefore a trend among States and localities to supplement fuel tax revenues with

alternative funding sources such as sales taxes. There is also a trend toward more flexible use of transportation revenues for a range of modal facilities needed to offer accessibility and mobility. Adequate and flexible funding is one of the greatest challenges in providing a transportation system that offers a high degree of accessibility to all Californians and the efficient movement of goods.

Energy, Air, Quality and Mobility

Due to energy security concerns over the past 30 years, petroleum reliance has been an important driver for new energy policies at the federal and state levels. The resulting energy policies have important reactions in California's transportation fuel market. California's severe air quality problem is also a major issue affecting transportation energy use. Federal and California laws aim to clean the air through changes in fuel use and emissions technologies.

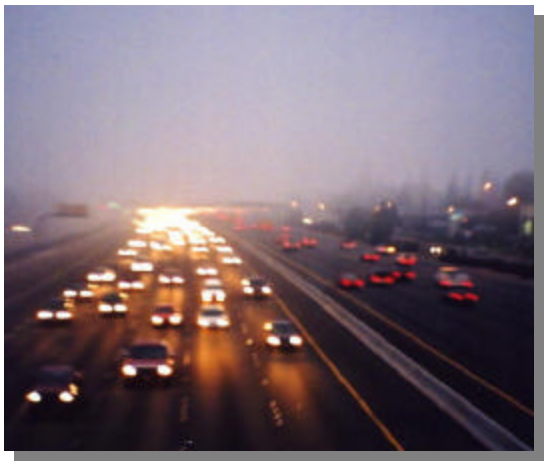


Photo: Ria Hutabarat

Over the past three decades, the composition of conventional petroleum fuels has changed in response to California's stringent fuel standards and vehicle emissions regulations. As a consequence of these efforts, both gasoline and diesel fuel sold in California is different to that sold in the rest of the country.

For several decades, the California Energy Commission has also worked with the California Air Resources Board and other public agencies to diversify the transportation fuel market by helping to develop a market for vehicles that use cleaner burning alternative fuels such as ethanol and hydrogen. Efforts to promote the alternatives to petroleum fuel have been limited by the current economics of the vehicle and fuel markets, and a lack of comprehensive information and integration with wider transportation policy and planning activities.

In addition to energy security and air quality, transportation energy is affected by other policies. Fuel taxes may have an impact on total state fuel consumption and alternative fuel vehicle adoption. Transportation road infrastructure policies have affected transportation energy consumption in moving toward their historic mission of improved vehicle access. Land use planning and policies that influence vehicle use, also shape transportation energy consumption.

Energy Policies Under Discussion

Energy policies in California include the following:

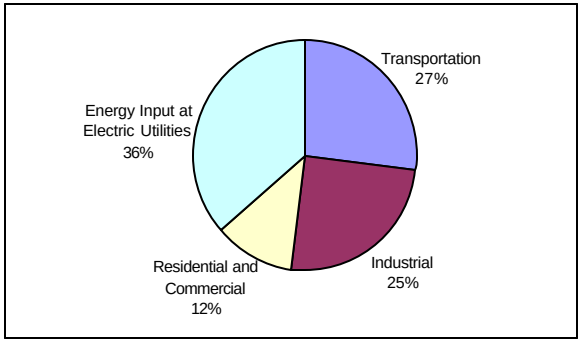
- Energy Security, Efficiency, and Diversity — U.S. fleet efficiency and alternative fuel policies and CA petroleum reduction laws decrease growth in petroleum consumption.
- Air Quality — U.S. Clean Air Act and CA regulations and incentives may reduce growth in petroleum consumption through emissions reductions programs.
- Fuel Taxes — U.S. and State fuel excise taxes at current levels have little impact
- Road Infrastructure — Other than recent federal funding strategies, policies encourage transportation fuel use
- Land Use Planning — CA leaves policymaking to local and regional governments. In WA and OR, policies may reduce transportation energy use.
- Transportation Behavior — Local strategies to reduce congestion may impact fuel use. CA State Government not heavily involved in these types of policies.

Economics of Transportation Energy

The transportation energy sector and the economy are dependent upon each other for growth and productivity. Transportation is essential to the timely, reliable, and efficient movement of people, goods, and services in both the domestic and global markets. The economy is dependent upon the transportation system and places a high demand on the transportation energy market, particularly oil. These issues can be explained in economic terms.

Costs, Benefits and Pricing

Although California has a high share of domestic oil, the state is increasingly reliant upon imported oil for the state's economy and transportation sector. Oil imports have large macroeconomic effects which may arise as a result of elevated prices, supply instability, price shocks and the transfer of wealth overseas.



U.S. Consumption of Energy, by Sector

Transportation energy consumption is associated with a number of costs and benefits such as effects on travel time, operating, and infrastructure costs in the transportation sector.

Fuel prices are also affected by market manipulation in a transportation energy market which is both competitive and monopolistic. OPEC possesses a partial monopoly over the crude oil market and is able to control output, prices, and price stability.

Economic Policy Options

Options for addressing macroeconomic effects of transportation energy impacts include reducing dependency on oil by encouraging alternative fuels, more diverse fuel sources, and energy conservation. Reducing dependence on foreign oil could improve stability in the fuel market and the U.S. economy, however this must be balanced against the cost of implementing alternatives. When there is greater economic stability, employment and output rates are higher.

The policies encouraging the use of alternative fossil fuels include gas taxes, tax incentives for alternative fueled vehicles,

Photo: David Faust

and investment in related infrastructure. More efficient or sustainable fuel consumption can provide benefits to the economy by reducing costs and creating new jobs and commercial opportunities.

Transportation is a derived demand, suggesting that policy options could also encompass access measures such as technology, planning and land use change.

The transportation energy sector has economic repercussions including macroeconomic effects, economic growth, monopolist behavior and oil dependency. These issues can be addressed through policies that enhance fuel price stability, consumption efficiency and fuel diversity.

Energy Supply & Demand

All markets aim to balance supply and demand, but California's markets for transportation fuels achieve this balance in a particularly precarious manner. California's tight and inflexible balance between supply and demand makes gasoline, in particular, susceptible to sharp swings in retail prices. The prices of other fuels are somewhat less volatile.

An Isolated Market

In California, transportation energy demand has only limited sensitivity to price. In the near term, very few trips can be deferred when fuel prices are high, so consumers see little choice but to absorb higher costs. Only large, sustained price changes spur comparable shifts in demand.

Energy supply is similarly inflexible. Refineries in California operate very near capacity, leaving little room for adjustment when one closes for maintenance or an emergency. During a decade of very low energy prices, refineries have made only the minimal investments necessary for additional capacity. The state's low fuel inventories and geographic isolation increase its vulnerability to price shocks when capacity is short.

Gasoline—which accounts for 60% of transportation energy use in California—is particularly susceptible to unstable prices. Stringent and evolving environmental standards prevent California from participating fully in global markets. As a result, California gasoline lacks access to futures markets that would moderate the tendency for prices to spike. Alternative fuels are not as dependent on refinery capacity, but suffer from similar problems.

No Silver Bullet

There are many potential policy options for rationalizing California's transportation energy markets. The state could cushion price shocks by expanding its energy distribution and storage infrastructure. Creation of a "strategic fuels reserve" could help foster a real futures market, helping the economy better manage risk. But the full environmental and security implications of this step have yet to be examined.

Effective measures on the demand side

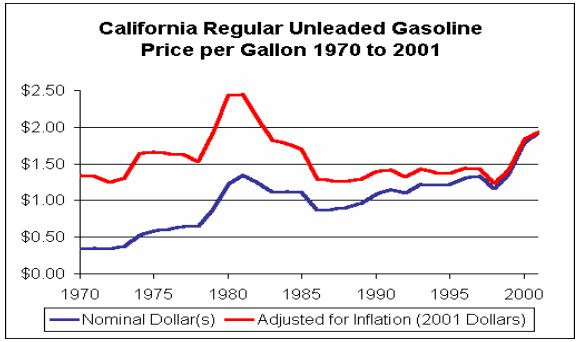


Photo: The Seeker

are difficult to design, but potentially carry broad economic, security, and environmental benefits. The state's proposed greenhouse gas emissions standards could play an important role in encouraging manufacturers to built more efficient and alternatively-fueled vehicles. California's successful program to promote the commercial viability of alternative fuels could be ramped up to a much larger scale.

Energy markets are inherently unstable. But a balanced program of supply-side and demand-side policies can help reduce California's unique price volatility.

Fuel Projections

Forecasts are an essential part of long-term planning for transportation and related endeavors. With the lengthy planning horizons required for major projects, using scarce resources wisely means ensuring that investments provide capacity where the greatest long term needs will be. Therefore, transportation planners must consider not only today's needs, but also what the demands on the system will be over the long-term.

Use of Energy Forecasts

Forecasts of fuel demand by fuel type, vehicle type, and VMT give agencies and industry the ability to project expected energy use, costs, revenues, consumer trends, emissions and other factors. These forecasts are needed to prioritize transportation policy options and evaluate strategies to address transportation energy consumption. Some of the key reasons for developing energy models to predict fuel supply and demand, include the need to:

- Improve energy security and understand the levels of risk;
- Devise programs to manage demand for fuel and travel;
- Assess and minimize environmental impacts; and
- Project transportation-related revenue.

Types of Energy Forecasts

Transportation energy consumption is a derived demand which stems from our desire and need to travel to work, educational and recreational opportunities, and to access goods and services. Growth in these demands is sensitive to population, income, employment levels, land use patterns, and other variables. Planners must therefore consider socio-economic forecasts in order to select policies and projects that meet future transportation demands within financial, environmental and other constraints.

Demand for transportation fuel also depends on the cost and availability of technology for fuel exploration, production and distribution, and vehicle development and use. These costs differ for different fuel types including petroleum, natural gas, electricity, alcohol and hydrogen.

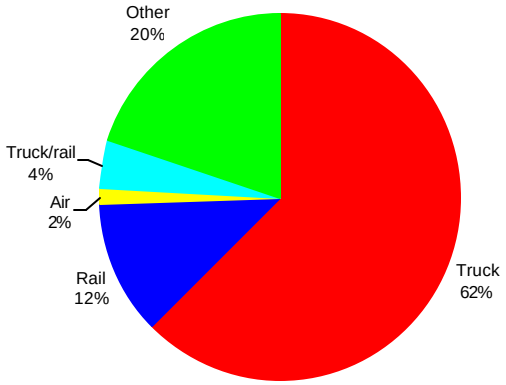
There are many models available to assist in energy planning as outlined in the California Energy Commission (CEC) report: *Reducing California's Petroleum Dependence*. The CEC's CALCARS model forecasts conventional and alternative fuel usage by personal light duty vehicles. Other models include the National Energy Modeling System (NEMS) by the Energy Information Administration (EIA); and the Environmental-Dynamic Revenue Analysis Model (E-DRAM) developed by University of California, Berkeley for the California Air Resources Board (ARB). E-DRAM has been used to assess economic impacts of petroleum reduction strategies in California.

Long Range Systems Impact on Energy Use

Long-range systems effects deal with transportation supply and demand for passengers and freight. Supply issues include system capacity and efficient operations, while demand issues include the amount of travel and the modes used. All are significant determinants of transportation energy consumption.

Demand for Travel and Energy

Demand for travel in California has increased rapidly. Population and employment in the state have been growing at about twice the national average over the past 30 years, and this trend is forecast to persist for at least the next 20 years. California continues to be dependent primarily on highway modes for passenger and freight transportation. This modal dependency is likely to increase if current development trends continue.



Mode Use for Shipments Originating Within California, 1997

New York City Transportation Management Center Center

Highway supply has increased somewhat over the past 30 years, but has not been able to grow with demand. Caltrans has made a concerted effort to better manage traffic operations to make the current system operate more efficiently. ITS technologies offer the promise of additional increases in system efficiency.

Long-Range Policies

A number of demand-side strategies have been tried over the past 20 years, from large capital investments in alternatives to the automobile to various types of transportation demand management measures. These strategies have had limited success.

The most effective policies appear to be the most controversial. Transportation policy options include:

1) Continuing current policies of operational improvements, transit investments, and small-scale demand reduction measures;
2) Large scale pricing of transportation facilities to reflect the true cost of congestion; and
3) Encouraging substitution of telecommunications for transportation.

No transportation system policy option alone will work well without supportive changes in land development.

Enhancement of commuter and urban rail facilities is one means of addressing travel demand

Technological Change

During the past 100 years, there has been enormous technological change in motor vehicles that has made them safer, cleaner, and more fuel efficient. Virtually all of the progress has been the result of evolutionary changes to gasoline-fueled vehicles with spark ignition engines. These technological changes encompass improvements in basic vehicle design, engines and drivetrains, vehicle safety, computerization, fuel development, and emissions control.

Exploring Alternatives

As motor vehicles evolved, there have been numerous proposals for revolutionary technological change, such as alternative engines and alternative fuels. While substantial progress has been made in developing these fuels and technologies, their success has been limited by an inability to achieve commercialization within the vehicle market.

Recent efforts by California agencies include proposals for transitions from gasoline to methanol during the 1980s and to electric vehicles during the 1990s. These efforts made great gains in vehicle development. They failed to achieve commercialization or a significant shift in the transportation petroleum market, however, due to overly optimistic performance and cost

Photo: California Fuel Cell Partnership

projections, in an environment where conventional technologies and fuels continued to evolve.

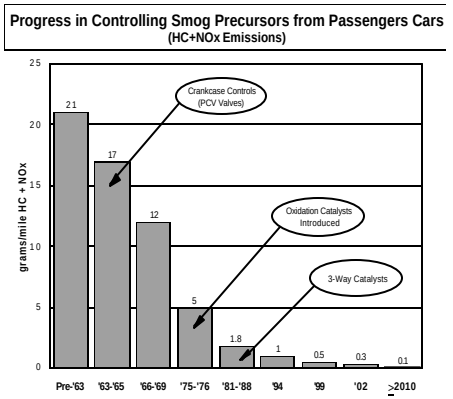
Developing Conventional Technologies

Over the past three decades, conventional vehicles have made enormous progress in fuel efficiency. While gasoline fueled vehicles remain a major source of urban smog and other air emissions in California, they have improved to such an extent that the gap between conventional and zero emissions has substantially diminished. With continued progress, it may eventually be possible to meet State air quality and greenhouse goals with no alternative propulsion systems or alternative fuels.

Current estimates of petroleum reserves are larger than ever. Continued progress in oil extraction technology may increase economically recoverable reserves and affect transportation fuel economics. Although increasing dependence on imported oil raises energy security concerns, the much higher costs of alternative energy sources suggests that strategies are needed to minimize the risk of oil supply disruptions without incurring prohibitive costs.

Horizon Technologies

Energy security, congestion and economics continue to drive the quest for improved technologies in vehicles and infrastructure. Several auto manufactures offer hybrid vehicles powered by both internal combustion and electric motors. These vehicles offer improved fuel efficiency and emissions, but at higher costs. Much research is focused on hydrogen as a future transportation fuel. The abundant supply and virtual zero emissions of hydrogen fuel cell vehicles offer great promise, but breakthroughs in technology and cost are required for commercial success.



Growth, Infrastructure, Land Use and Development

Land use is a key determinant of travel demand. The employment and population densities of land use have significant effects on the total amount of travel, the types of modes used, and therefore the amount of energy used for transportation. Good urban planning and design encourage travelers to use non-auto modes.

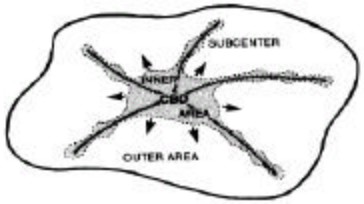
Land Use Planning is Key to Reducing Energy Consumption

While effective land use planning is key to reducing transportation energy demand, there is limited opportunity to intervene at the state level, and California has been developing in the opposite direction. Most growth has occurred at low-densities, and this trend is likely to continue. Residents continue to move to low-density areas for lifestyle, schooling, and housing affordability reasons. Businesses often follow residents, leading to decreased employment densities.

Land use in California is controlled locally, and local governments' fiscal priorities motivate them to zone for commercial development, which brings in more tax revenue

Photo: Weinstein Copeland Architects

than housing. Fiscal incentives and local control of land use make it difficult to coordinate land use policy at a regional — let alone a state — level.



The transportation planning process seldom takes land use planning into account. Although some regional planning efforts have started to look at alternative land development scenarios, most regional plans take land use as a given, being determined by localities.

Changes and Coordination Are Needed

There are emerging movements in California and other states to encourage energy-efficient land use. Local growth control measures and smart growth have become more popular in California. Other states provide examples of top-down growth control.

Coordination of transportation and land use planning will require legislative changes at the state level, including changes to fiscal policy for localities. Nonetheless, the state can act now to encourage smart growth, promote effective transit-oriented development practices, and encourage greater consideration of land use in the transportation planning process.

San Francisco Municipal Light Rail

Transportation Planning & Energy

Transportation planning and land use development policies influence energy consumption through effects on travel demand, activity location, mode choice and traffic congestion. Historically, federal and state policies encouraged highway based transportation systems and suburbanization of metropolitan regions. In California, these factors contribute to high levels of energy consumption, and provide the framework within which transportation planning occurs.

Transportation Planning and Financing

Transportation planning and programming occurs at the federal, state, regional and local levels. In the past decade, federal transportation funding under ISTEA/TEA-21 provided more than $300 billion for the completion of the interstate system, rehabilitation of existing infrastructure, transit development, and programs for congestion mitigation, alternative fuels and air quality improvement. All of these programs have impacts on transportation energy consumption in the United States.

A major influence of federal planning structures is the requirement for implementing state and regional integrated transportation plans and programs. In California, Regional Transportation Plans (RTPs) provide for long-term, multi-modal transportation development which links a range of objectives. While energy is not a specific objective within these processes, other economic, social and environmental objectives have energy implications. For example, regional planning efforts supporting smart growth tend to facilitate greater transportation energy efficiency.

Movement toward devolution of planning and funding may also result in more integrated and smart growth transportation alternatives. However, a shift from gas taxes toward general or sales taxes as funding sources for local transportation plans may have a negative impact in terms of providing a market tool to encourage greater fuel conservation and efficiency.

Energy Objectives

While many planning objectives at the state, regional and local level have an impact on energy, there is a lack of explicit energy-related goals and criteria for transportation planning within California. This inadequacy might be addressed by introducing energy as a decision making criteria for local, regional and state transportation planning and funding. It may also be addressed by including energy concerns in requirements for environmental impact assessment processes.

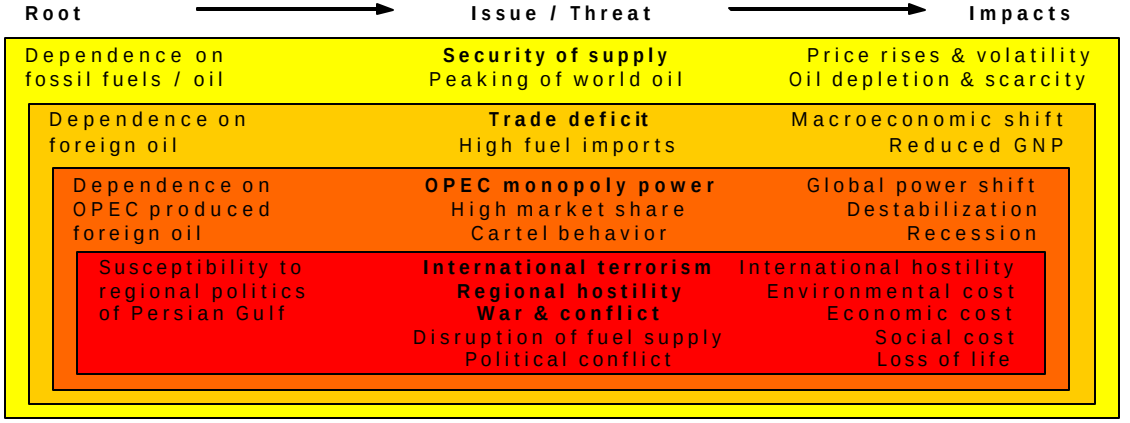
Sustainability and Impacts

Implementing sustainable development in California's transportation energy sector requires an understanding of the sector's impacts on the economy, environment, and society. The transportation sector comprises 34 percent of total energy use in California, this demand is almost completely met using petroleum-based fuels. Transportation fuels provide substantial benefits to users and society as reflected in people's willingness to pay for current levels and patterns of mobility. However, conventional fuels also impose a range of risks and negative impacts that should be acknowledged and addressed in order to ensure that the transportation system provides the most socially optimal outcomes.

Economic, Social and Environmental Impacts

Transportation energy is a commodity that affects the prices of other commodities. Escalation or volatility in the price of oil translates into higher production and transport costs, making goods more expensive and less competitive in the market. At a large enough scale, shifts in the price of transportation energy can result in macroeconomic damage.

This economic vulnerability is reinforced by a lack of available and competitively priced mode and fuel choices, which means that demand for petroleum fuels is virtually inelastic. Increased dependence on imported oil increases the risk of damage caused by price shocks related to external events such as price manipulation, political unrest and terrorist activities.



Transportation energy patterns also have environmental and social effects. Fuel emissions damage air quality and contribute to climate change effects, while fuel leaks and spills damage water quality in affected areas. The uneven distribution of these impacts may result in social equity concerns as these impacts are often most severe in low-income and minority neighborhoods near major roadways and refineries.

Cross-Cutting Policy Considerations

In order to capture the benefits of transportation energy while minimizing risks and negative impacts on the economy, environment and society, a range of potential policy options may be considered:

- Continuing technological advancements to increase fuel efficiency and economy;
- Encouraging diversity of fuel supplies to reduce the risk of disruption and price volatility;
- Fostering fuel flexibility, market penetration of alternative fueled vehicles, and alternative fuel infrastructure investment; and
- Promoting conservation and efficiency through public education, smart growth planning, and alternative travel pattern programs.

Funding for this report was provided by
the California Department of Transportation,
Department of Policy Analysis and Research

California Department of Transportation Team:

Reza Navai, PhD, Project Director
Malcolm Gilmour, Project Manager

Principal Authors:

Jack Faucett Associates, Inc.
Michael Lawrence, Project Manager
Ria Hutabarat, Project Coordinator
Todd Goldman
Krute Singa
Paul Nguyen
Justine Lam
Cynthia McCormick

Dowling, Inc.
David Reinke
Christopher Ferrell

Sierra Research
Thomas Austin
Robert Dulla

TIAX, LLC.
Erin Kassoy
Fanta Kamakaté
Michael Jackson

JACK FAUCETT ASSOCIATES

July 2003

Cover Image Credits
Top—Sacramento Regional Transit
Center—CNN
Bottom—Microsoft Clip Art

Back Cover
Top— National Science Teachers Association
Center—Justine Lam
Bottom— Ria Hutabarat

JACK FAUCETT ASSOCIATES